

ADAC38050

HDL-TR-1788

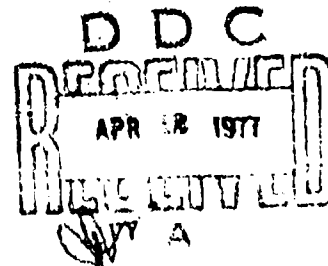
(12) 2

RARE EARTH ION-HOST LATTICE INTERACTIONS
13. Lanthanides in $YAlO_3$

Host Lattice Interactions: J. Lanthanides in $YAlO_3$,
J. N. Koryntsev, and Donald E. Morten

February 1977

COPY AVAILABLE TO DDC DOES NOT
PERMIT FULLY LEGIBLE PROTECTION



U.S. Army Material Development
and Readiness Command
HARRY DIAMOND LABORATORIES
Adelphi, Maryland 20783

APPROVED FOR PUBLIC RELEASE. DISTRIBUTION UNLIMITED.

ADAC38050
DDC FILE COPY

DISCLAIMER NOTICE

THIS DOCUMENT IS BEST QUALITY PRACTICABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

Citation of manufacturers' or trade names does not constitute an official indorsement or approval of the use thereof.

Destroy this report when it is no longer needed. Do not return it to the originator.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER HDL-TR-1788	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Rare Earth Ion-Host Lattice Interactions, 13. Lanthanides in $YAlO_3$.		5. TYPE OF REPORT & PERIOD COVERED Technical Report
6. AUTHOR(s) Clyde A. Morrison Nick/Karayianis Donald E. Wortman		7. PERFORMING ORG. REPORT NUMBER
8. PERFORMING ORGANIZATION NAME AND ADDRESS Harry Diamond Laboratories 2800 Powder Mill Road Adelphi, MD 20783		9. CONTRACT OR GRANT NUMBER(s) DA: 1T161102AH46
10. CONTROLLING OFFICE NAME AND ADDRESS Commander US Army Electronics Command Ft Monmouth, NJ 07703		11. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Program: 6.11.02.A
12. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		13. REPORT DATE February 1977
14. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		15. NUMBER OF PAGES 41
16. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		17. SECURITY CLASS. (of this report) UNCLASSIFIED
18. SUPPLEMENTARY NOTES HDL Project: 308637 DRCMS Code: 611102.11.H46H1		19. DECLASSIFICATION/DOWNGRADING SCHEDULE
20. KEY WORDS (Continue on reverse side if necessary and identify by block number) Yttrium aluminate Optical absorption and fluorescence spectra Crystal field parameters Rare earth spectra Lanthanide spectra		
21. ABSTRACT (Continue on reverse side if necessary and identify by block number) Phenomenological even-fold crystal field parameters, B_{km} , are obtained for triply ionized Nd, Tb, Dy, Ho, Er, and Tm in $YAlO_3$ by diagonalizing a $C_8(C_{1h})$ crystal field Hamiltonian in a free-ion wave-function basis. These parameters are reduced to give the part of the crystal field components, A_{km} , due solely to the crystal lattice, and new B_{km} are then calculated for all the lanthanides by using previously derived ρ_k^i , where $B_{km} = \rho_k^i A_{km}$.		

DD FORM 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

100050

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

The latter B_{km} are used to calculate the energy levels of the lower J-multiplets for the lanthanide series in $YA10$.

ADDITIONAL

NOTE

DO NOT

UNCLASSIFIED

INSTRUCTIONS

BY

SIGNATURE

DATE

A 23

2

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

CONTENTS

	Page
1. INTRODUCTION	5
2. CALCULATIONS	5
3. SUMMARY	11
LITERATURE CITED	38
DISTRIBUTION	39

TABLES

I	Phenomenological Crystal Field Parameters, B_{km} , for Triply Ionized Lanthanides in $YAlO_3$	7
II	Values for $a_k = 1 - k \langle r^k \rangle (1 - a_k)$ in \AA^k	8
III	Crystal Field Parameters, B_{km} , for Triply Ionized Lanthanides in $YAlO_3$	10
IV	Crystal Field Parameters, B_{km} , and Energy Levels for Pr^{3+} in $YAlO_3$	12
V	Energy Levels and Phenomenological Crystal Field Parameters for Nd^{3+} in $YAlO_3$	14
VI	Crystal Field Parameters, B_{km} , and Energy Levels for Nd^{3+} in $YAlO_3$	15
VII	Crystal Field Parameters, B_{km} , and Energy Levels for Pm^{4+} in $YAlO_3$	16
VIII	Crystal Field Parameters, B_{km} , and Energy Levels for Sm^{3+} in $YAlO_3$	18
IX	Crystal Field Parameters, B_{km} , and Energy Levels for Eu^{3+} in $YAlO_3$	20
X	Crystal Field Parameters, B_{km} , and Energy Levels for Gd^{3+} in $YAlO_3$	22
XI	Energy Levels and Phenomenological B_{km} for Tb^{3+} in $YAlO_3$	23
XII	Crystal Field Parameters, B_{km} , and Energy Levels for Tb^{3+} in $YAlO_3$	24
XIII	Energy Levels and Phenomenological Crystal Field Parameters for Dy^{3+} in $YAlO_3$	26

TABLES (CONT'D)

	<u>Page</u>
XIV Crystal Field Parameters, B_{km} , and Energy Levels for Dy^{3+} in $YAlO_3$	27
XV Energy Levels and Phenomenological Crystal Field Parameters for Ho^{3+} in $YAlO_3$	28
XVI Crystal Field Parameters, B_{km} , and Energy Levels for Ho^{3+} in $YAlO_3$	29
XVII-XVIII Energy Levels and Phenomenological Crystal Field Parameters for Er^{3+} in $YAlO_3$	30-31
XIX Crystal Field Parameters, B_{km} , and Energy Levels for Er^{3+} in $YAlO_3$	32
XX Energy Levels and Phenomenological Crystal Field Parameters for Tm^{3+} in $YAlO_3$	33
XXI Crystal Field Parameters, B_{km} , and Energy Levels for Tm^{3+} in $YAlO_3$	34
XXII Amplitudes, Crystal Field Components, A_{km} in $cm^{-1} \text{ \AA}^{-k}$, of Spherical Decomposition of $YAlO_3$ Lattice Sums	36
XXIII Amplitudes, Crystal Field Components, A_{km} in $cm^{-1} \text{ \AA}^{-k}$, of Spherical Decomposition of $YAlO_3$ Lattice Sums for Even Values of k	37

1. INTRODUCTION

The optical spectra of a number of triply ionized lanthanides in yttrium orthoaluminate (YAlO_3) have been reported.¹⁻⁶ Because of the excellent laser properties of this material,¹ we have examined these reported spectra in order to obtain a unified theory of the crystal field interactions at the laser ion site in YAlO_3 . In this report, phenomenological crystal field parameters, B_{km} , for triply ionized Nd, Tb, Dy, Ho, Er, and Tm were obtained by diagonalizing a $C_s(C_{1h})$ crystal field Hamiltonian in a free-ion wave-function basis. The parameters were reduced to give the part of the crystal field components, A_{km} , due solely to the crystal lattice, and new B_{km} were then calculated for all the lanthanides by using previously derived⁷ ρ_k , where $B_{km} = \rho_k A_{km}$. These B_{km} were then used to calculate the energy levels of the lower J-multiplets for the lanthanide series in YAlO_3 .

2. CALCULATIONS

The point group symmetry⁸ at the yttrium site in YAlO_3 is $C_s(C_{1h})$, which includes a reflection plane in addition to the identity operation.

¹M. Bass and M. J. Weber, *Laser Focus*, 7 (1971), 34-36.

²M. J. Weber and T. E. Varitimos, *J. Appl. Phys.*, 42 (1971), 4996-5005.

³Kh. S. Bagdasarov, A. A. Kaminskii, and G. I. Rogov, *Sov. Phys. Doklady*, 14 (1969), 346-348.

⁴J. L. Berg, *High Resolution Low Temperature Spectra of Tb^{3+} in YAlO_3* , Master's Thesis, Air Force Institute of Technology, Wright-Patterson Air Force Base, OH (June 1973).

⁵V. A. Antanov, P. A. Arsenev, K. E. Bienert, and A. V. Potemkin, *Phys. Status Solidi A*, 19 (1973), 289-299.

⁶V. L. Donlan and A. A. Santiago, Jr., *J. Chem. Phys.*, 57 (1972), 4717-4723.

⁷D. E. Wortman, C. A. Morrison, and N. Karayianis, *Rare Earth Ion-Host Lattice Interactions II. Lanthanides in $\text{Y}_3\text{Al}_5\text{O}_{12}$* , Harry Diamond Laboratories TR-1773 (August 1976).

⁸R. Diehl and G. Brandt, *Materia Research Bulletin*, 10 (1975), 85-90.

If the z-axis is taken perpendicular to the reflection plane, the crystal field Hamiltonian is of the form

$$H_x = \sum_{km} B_{km} C_{km}, \quad k = 2, 4, 6; m = 0, \pm 2, \dots, \pm k, \quad (1)$$

where the B_{km} for $m \neq 0$ may be complex. With no loss in generality, we chose real B_{20} and imaginary $B_{40} \pm 0$.

The crystal field Hamiltonian was diagonalized in the low-lying J-multiplets of free-ion wave functions,⁹ and the B_{km} were varied to obtain best fits between theoretical and experimental energy levels reported for Nd,^{2,3} Tb,⁴ Dy,⁵ Ho,⁵ Er^{5,6} and Tm.⁵ The resultant best-fit parameters are given in table I, where the next to last four columns give the number of J-multiplets diagonalized, the number of levels in these multiplets, the number of experimental energies used, and finally the rms deviation between these energies and their corresponding theoretical energies. The multiplets included for each ion were (1) the ⁴I term, ⁴F_{3/2}, and ⁴F_{9/2} for Nd; (2) the ⁷F term and ¹D₄ for Tb; (3) ⁸H_{15/2}, ^{13/2, ^{11/2, ^{5/2 and ⁶F_{7/2}, ^{5/2 for Dy; (4) ⁵I_{8,7,6,5} and ⁵F_{4,3} for Ho; (5) the ⁴I term, ⁴F_{9/2}, and ⁴S_{3/2} for Er; and (6) the ³H term, ³F_{3/2}, and ¹G₄ for Tm. The lack of sufficient data in some cases plus ambiguities owing to overlapping multiplets governed the choice of}}}}

²M. J. Weber and T. E. Varitimos, *J. Appl. Phys.*, **42** (1971), 4996-5005.

³Kh. S. Bagdasarov, A. A. Kaminskii, and G. I. Rogov, *Sov. Phys. Doklady*, **14** (1969), 346-348.

⁴J. L. Berg, *High Resolution Low Temperature Spectra of Tb³⁺ in YAlO₃*, Master's Thesis, Air Force Institute of Technology, Wright-Patterson Air Force Base, OH (June 1973).

⁵V. A. Antanov, P. A. Arsenev, K. E. Bienert, and A. V. Potamkin, *Phys. Status Solidi A*, **19** (1973), 289-299.

⁶V. L. Donlan and A. A. Santiago, Jr., *J. Chem. Phys.*, **57** (1972), 4717-4723.

⁹W. T. Carnall, P. R. Fields, and K. Rajnak, *J. Chem. Phys.*, **49** (1968), 4412-4455.

Ion	E ₀	B ₀			B ₁			B ₂			Level (eV)	Wave length (Å)		
		Real	Imag.	Ratio	Real	Imag.	Ratio	Real	Imag.	Ratio				
H ⁺	314	-18	-135	525	-21	-575	-112	-346	-155	114	321	52	33	2430
He	567	-233	-1060	427	-368	-32	-751	-317	-425	-440	-538	91	53	2160
Li	553	-163	-382	350	151	-495	-363	156	-153	613	-97	440	31	3110
Be	716	-248	-938	384	-63	-360	-963	211	-214	-41	563	16	36	1735
B	547	-3	-793	491	-32	-516	-877	-304	-175	35	410	32	43	2110
C	431	-179	-833	346	-116	-559	-72	-241	-180	54	17	23	33	1760
N	675	-76	-754	480	-47	-445	-73	-72	-184	601	59	-113	34	1730

[illegible]

multiplets and experimental energies that were used in the fitting procedure. Table I, line 6, gives the set of initial B_{km} for Er that were chosen to begin the fitting procedure. For starting parameters, previously reported parameters for Er:yttrium aluminum garnet (YAG)¹⁰ were used. Since the YAG crystal field is real, imaginary $B_{4,2}$ was arbitrarily set at 200 cm^{-1} .

Subsequent choices for starting parameters for the other ions were chosen by scaling the Ho parameters, which were obtained by averaging the best-fit Dy and Er phenomenological B_{km} , according to the ρ_k in table II. These ρ_k , given by

TABLE II. VALUES FOR $\rho_k = \tau^{-k} \langle r^k \rangle (1 - \sigma_k)$
IN \AA^k TO CONVERT LATTICE SUMS
CRYSTAL FIELD COMPONENTS, A_{km} ,
TO CRYSTAL FIELD PARAMETERS, B_{km} ,
AS $B_{km} = \rho_k A_{km}$

Ion	ρ_2	ρ_4	ρ_6
Co	0.1841	0.2546	2.3617
Pd	0.1756	0.6464	1.8754
Nd	0.1706	0.5776	1.5897
Pr	0.1679	0.5339	1.4218
Sm	0.1668	0.5069	1.3210
Eu	0.1666	0.4836	1.2503
Gd	0.1668	0.4656	1.1873
Tb	0.1673	0.4990	1.1232
Dy	0.1681	0.4361	1.0614
Hf	0.1692	0.4217	1.0119
Er	0.1706	0.4126	0.9826
Ho	0.1722	0.4053	0.9669
Lu	0.1737	0.3938	0.9370

¹⁰C. A. Morrison, D. E. Wortman, and N. Karayianis, *J. Phys. C: Solid State Phys.*, **9** (1976), L191.

$$\rho_k = \tau^{-k} \langle r^k \rangle (1 - \sigma_k) , \quad (2)$$

are rare-earth-ion dependent and relate the B_{km} to the lattice sum field A_{km} by

$$B_{km} = \rho_k A_{km} , \quad (3)$$

where it is assumed that the A_{km} are host dependent only. The $\langle r^k \rangle$ are smoothed values of Freeman and Watson,¹¹ the σ_k are linearly interpolated calculations of Erdos and Kang,¹² and the τ are quadratically fit wave-function expansion parameters found in studies of lanthanides in CaWO_4 .¹³ The B_{km} for the lanthanide series obtained by using these ρ_k values of table II in equation (3) and the B_{km} for Dy and Er of table I are given in table III.

Energy levels calculated by using the B_{km} of tables I and III for the lowest-lying six to eight multiplets of the lanthanides in YAlO_3 are given in tables IV to XXI.

To make intensity calculations, some estimates of the odd-fold (odd- k) A_{km} are necessary. These can be obtained by appropriate lattice sums.¹⁴ In this work, we have performed the lattice sums for YAlO_3 using the x-ray data of Diehl and Brandt⁸ for oxygen charges $q_O = -1$ and -2 ; the results are given in table XXII. The one-fold field, A_{1m} , was not

⁸R. Diehl and G. Brandt, *Materia Research Bulletin*, 10 (1975), 85-90.

¹¹A. J. Freeman and R. E. Watson, *Phys. Rev.*, 127 (1962), 2058-2075.

¹²P. Erdos and J. H. Kang, *Phys. Rev. B*, 6 (1972), 3393-3408.

¹³R. P. Leavitt, C. A. Morrison, and D. E. Wortman, *Rare Earth Ion-Host Crystal Interactions 3. Three-Parameter Theory of Crystal Fields*, Harry Diamond Laboratories TR-1673 (June 1975).

¹⁴N. Karayianis and C. A. Morrison, *Rare Earth Ion-Host Lattice Interactions 1. Point Charge Lattice Sum in Scheelites*, Harry Diamond Laboratories TR-1648 (October 1973).

TABLE III. CRYSTAL FIELD PARAMETERS, $B_{k_{\text{CF}}}$, FOR TRIPLY IONIZED LANTHANIDES IN YAIO_3

[illegible]

included because of its slow convergence. By appropriate rotations of the coordinate system chosen for the calculation of the A_{km} of table XXII, different sets of A_{km} can be generated. Thus by appropriate rotation, the sets of A_{km} for $q_0 = -1$ and -1.5 given in table XXIII were calculated. Since the A_{km} are linear functions of q_0 , a value of q_0 can be chosen by using equation (3) and the ρ_k of table II to obtain a best fit of calculated B_{km} to phenomenological B_{km} . The results of this calculation give $q_0 = -1.52$, and the corresponding A_{km} are reported elsewhere.¹⁵

3. SUMMARY

Reported energy levels for Nd, Tb, Dy, Ho, Er, and Tm were used to obtain phenomenological B_{km} that yielded least-rms deviations between these levels and levels calculated by using the Hamiltonian given in equation (1) and unpublished theoretical methods and computer programs. These parameters were then scaled to get even- k B_{km} for the entire lanthanide series in $YAlO_3$. It is expected that these B_{km} will at least serve as starting parameters for the analysis of yet unreported ions in $YAlO_3$. No intensities were calculated because the symmetry of the Y^{3+} site was low and because no reasonable higher symmetry approximation could be made as was done⁷ for the lanthanides in YAG.

⁷D. E. Wortman, C. A. Morrison, and N. Karayianis, *Rare Earth Ion-Host Lattice Interactions* 11. *Lanthanides in $Y_3Al_5O_{12}$* , Harry Diamond Laboratories TR-1773 (August 1976).

¹⁵N. Karayianis, D. E. Wortman, and C. A. Morrison, *Solid State Comm.*, **18** (1976).

BEST AVAILABLE COPY

TABLE IV. CRYSTAL FIELD PARAMETERS, B_{km} , AND ENERGY LEVELS FOR Pr^{3+} IN $YAlO_3^a$ (CONT'D)

	FREE ION	PCT PURE	2Mμ	THEO. ENERGY	EXP. ENERGY
55	15 4	93.4	2	9520.5	0.0
56	15 4	93.3	2	9603.6	0.0
57	15 4	93.8	0	9721.3	0.0
58	15 4	93.5	0	9795.6	0.0
59	15 4	93.6	2	9893.0	0.0
60	15 4	93.5	0	10378.6	0.0
61	15 4	93.6	0	10164.4	0.0
62	15 4	93.5	2	10255.4	0.0
63	15 4	93.5	0	10507.3	0.0
64	10 2	100.0	0	16432.2	0.0
65	10 2	93.9	0	16715.0	0.0
66	10 2	93.7	2	16777.1	0.0
67	10 2	93.9	0	17015.0	0.0
68	10 2	93.9	0	17114.9	0.0

^aThese B_{km} values were obtained by scaling the Ho parameters by the χ_k value of table II. The Ho parameters were obtained by a linear interpolation of the Dy and Er phenomenological B_{km} values.

TABLE V. ENERGY LEVELS AND PHENOMENOLOGICAL CRYSTAL FIELD PARAMETERS FOR Nd^{3+} IN YAlO_3^d

ND 17 VALS NEHER DATA 6 MULTIPLETS FROM DY & ER HOME 2/16/75									
FINAL PPM AND CENTROS. CRYSTAL = 5770.8									
-14.035 = 320 -1344.537 = 840 -221.130 = 242									
-1132.409 = 863 -347.745 = 862 -155.434 = 862 1214.405 = 454									
41 9/2	334.1								
4111/2	2217.2								
4113/2	4131.5								
4115/2	6142.4								
4F 3/2	11464.3								
4F 9/2	14750.3								
1 41 7/2	34.3	1	19 4115/2	32.4	1	5744.9	5760.0*		
2 41 9/2	113.2	1	20 4115/2	46.7	1	5496.0	5496.0		
3 41 9/2	213.2	1	21 4115/2	39.3	1	6111.0	6111.0		
4 41 9/2	442.6	1	22 4115/2	39.3	1	6192.0	6192.0		
5 41 9/2	805.1	1	23 4115/2	32.7	1	6242.0	6242.0		
6 4111/2	2331.4	1	24 4115/2	44.6	1	6317.0*	6317.0*		
7 4111/2	2103.0	1	25 4115/2	43.1	1	-0.0	-0.0		
8 4111/2	2159.0	1	26 4115/2	32.6	1	11413.0	11413.0		
9 4111/2	2350.1	1	27 4F 3/2	41.7	1	11542.0	11542.0		
10 4111/2	2313.4	1	28 4F 3/2	49.4	1	14674.0	14680.0		
11 4111/2	2367.0	1	29 4F 9/2	30.4	1	14722.3	14730.0*		
12 4113/2	3954.2	1	30 4F 1/2	31.4	1	14763.0	14763.0		
13 4113/2	4024.7	1	31 4F 3/2	32.4	1	14402.5	14795.0*		
14 4113/2	4072.1	1	32 4F 3/2	33.4	1	14730.5	14924.0		
15 4113/2	4193.2	1	33 4F 9/2	100.0	1				
16 4113/2	4242.1	1							
17 4113/2	4317.8	1							
18 4113/2	4423.5	1							
19 4113/2	4473.5	1							
CENTROS. CRYSTAL = 5770.8 FREE ION = 5770.9									

^a The calculated and experimental energy levels rms deviation is 6.786 cm^{-1} .

TABLE VII. CRYSTAL FIELD PARAMETERS, B_{km} , AND ENERGY LEVELS FOR Nd^{3+} IN $YAlO_3$ (CONT'D)

FREE ION	PCT PURE	2MU	THEO. ENERGY	EXP. ENERGY
57 51 4	14.1	2	6121.0	6.0
58 51 4	14.4	2	6174.7	6.0
59 51 4	14.8	2	6184.8	6.0
60 51 4	14.1	2	6170.4	6.0
61 51 4	14.1	2	6111.4	6.0
62 51 3	14.9	1	7451.3	6.0
63 51 3	14.2	1	7425.3	6.0
64 51 3	14.2	2	7476.0	6.0
65 51 3	14.7	2	7506.3	6.0
66 5F 1	14.9	3	12466.4	6.0
67 5F 1	14.3	3	12464.1	6.0
68 5F 1	14.3	3	12454.0	6.0

^a These B_{km} values were obtained by scaling the Ho parameters by the ρ_k value of table II. The Ho parameters were obtained by a linear interpolation of the Dy and Er phenomenological B_{km} values.

TABLE VIII. CRYSTAL FIELD PARAMETERS, B_{km} , AND ENERGY LEVELS FOR Sm^{3+} IN YAlO_3^a

SM $4f^5$ VALUES, SCALED FROM $4f^6$ DETERMINED BY AVERAGING OY AND ER HOMED RESULTS									
UNIT: B_{km} AND CENTERED IN $Q = 0.00$									
536,000 = 829 -104,000 = 1.2 -1025,000 = 840 -575,000 = 842 397,000 = 844 -61,000 = 844 -666,000 = 844									
-1064,000 = 663 -55,000 = 652 -251,000 = 862 773,000 = 864 -52,000 = 864 -271,000 = 866 177,000 = 866									
6H 5/2	6H 7/2	6H 9/2	6H 11/2	6H 13/2	6H 15/2	6H 17/2	6H 19/2	6H 21/2	6H 23/2
134.0	1143.0	2334.0	3737.0	5039.0	6335.0	6550.0	6700.0	7116.0	7935.0
3147.0									
FREQ. 10 ³	PCT. 10 ³	PCT. 10 ³	PCT. 10 ³	PCT. 10 ³	PCT. 10 ³	PCT. 10 ³	PCT. 10 ³	PCT. 10 ³	PCT. 10 ³
EXP. ENERGY	THEO. ENERGY	EXP. ENERGY	THEO. ENERGY	EXP. ENERGY	THEO. ENERGY	EXP. ENERGY	THEO. ENERGY	EXP. ENERGY	THEO. ENERGY
1 6H 5/2	97.1	1	-67.4	19 6H 13/2	97.7	1	4.94.3	1	4.94.3
2 6H 5/2	96.5	1	94.3	20 6H 13/2	96.5	1	4.94.1	1	4.94.1
3 6H 5/2	97.2	1	214.4	21 6H 13/2	97.7	1	5.22.7	1	5.22.7
4 6H 7/2	95.1	1	381.5	22 6H 13/2	95.9	1	5.62.4	1	5.62.4
5 6H 7/2	95.6	1	1132.1	23 6H 13/2	97.4	1	5.11.3	1	5.11.3
6 6H 7/2	96.7	1	1137.1	24 6H 13/2	97.5	1	5.59.5	1	5.59.5
7 6H 7/2	94.5	1	1332.1	25 6H 13/2	97.3	1	5.35.2	1	5.35.2
8 6H 9/2	97.1	1	221.1	26 6H 15/2	93.9	1	6.21.2	1	6.21.2
9 6H 9/2	96.3	1	231.1	27 6H 15/2	93.1	1	6.36.2	1	6.36.2
10 6H 9/2	92.9	1	236.1	28 6H 17/2	93.9	1	6.36.4	1	6.36.4
11 6H 9/2	97.1	1	247.1	29 6H 19/2	92.9	1	6.72.5	1	6.72.5
12 6H 9/2	92.7	1	254.1	30 6H 19/2	92.5	1	6.72.3	1	6.72.3
13 6H 11/2	97.3	1	342.1	31 6H 19/2	92.9	1	6.73.4	1	6.73.4
14 6H 11/2	95.9	1	342.1	32 6H 19/2	92.9	1	6.73.4	1	6.73.4
15 6H 11/2	97.0	1	342.1	33 6H 19/2	92.9	1	6.73.4	1	6.73.4
16 6H 11/2	97.5	1	342.1	34 6H 19/2	91.2	1	6.73.4	1	6.73.4
17 6H 11/2	94.2	1	342.1	35 6H 19/2	91.2	1	6.73.4	1	6.73.4
18 6H 11/2	94.2	1	342.1						

^a See footnote at end of table.

TABLE VIII. CRYSTAL FIELD PARAMETERS, B_{km} , AND ENERGY LEVELS FOR Sm^{3+} IN YAlO_3 ^a (CONT'D)

FREE ION	PCT	THRE	2MU	THEO.ENERGY	EXP.ENERGY
36 6H15/2	64.9	1		6422.3	0.0
37 6F 5/2	34.7	1		7145.8	0.0
38 6F 5/2	34.2	1		7170.6	0.0
39 6F 5/2	34.5	1		7236.4	0.0
40 6F 7/2	37.2	1		7900.2	0.0
41 6F 7/2	37.2	1		8615.4	0.0
42 6F 7/2	37.7	1		9049.8	0.0
43 6F 7/2	36.3	1		8116.8	0.0
44 6F 4/2	39.3	1		9115.8	0.0
45 6F 3/2	34.6	1		9157.4	0.0
46 6F 7/2	34.4	1		9132.1	0.0
47 6F 3/2	34.7	1		9216.5	0.0
48 6F 3/2	34.2	1		9244.4	0.0

^a These B_{km} values were obtained by scaling the no parameters by the B_k value of table II. The no parameters were obtained by a linear interpolation of the Dy and Er phenomenological B_{km} values.

TABLE IX. CRYSTAL FIELD PARAMETERS, B_{km} , AND ENERGY LEVELS FOR Eu^{3+} IN YAlO_3^a

EU IN VAL03. SCALED BKM FROM HQ DETERMINED BY AVERAGING DV AND EX-POLED RESULTS									
INIT. BKM AND CENTRIDS: Q = -0.006									
514.000 = 820		-163.000 = 822		-285.000 = 840		-552.000 = 842		301.000 = 842	
-1006.000 = 860		-52.000 = 862		-237.000 = 862		731.000 = 864		-49.000 = 864	
-639.000 = 864		168.000 = 866							
FREE ION	PCT PURE	2F5	THEO. ENERGY	EXP. ENERGY					
1 7F 0	97.8	0	52.7	0.0	26 7F 5	75.1	0	3454.7	0.0
2 7F 1	96.3	2	332.5	0.0	27 7F 5	94.6	2	3406.7	0.0
3 7F 1	98.0	2	422.6	0.0	28 7F 5	93.0	2	3462.7	0.0
4 7F 1	96.8	0	525.5	0.0	29 7F 5	93.5	0	3482.8	0.0
5 7F 2	94.0	0	1004.8	0.0	30 7F 5	32.6	0	4096.1	0.0
6 7F 2	96.7	2	1036.7	0.0	31 7F 5	95.3	2	4192.3	0.0
7 7F 2	92.2	2	1119.4	0.0	32 7F 5	95.0	2	4114.5	0.0
8 7F 2	95.0	0	1159.8	0.0	33 7F 5	92.1	0	4134.6	0.0
9 7F 2	96.8	0	1323.9	0.0	34 7F 5	37.7	0	4216.3	0.0
10 7F 3	96.7	2	1402.7	0.0	35 7F 5	97.2	2	4214.2	0.0
11 7F 3	91.6	0	1410.4	0.0	36 7F 5	97.8	2	4285.3	0.0
12 7F 3	96.2	2	1922.3	0.0	37 7F 6	97.1	2	4911.2	0.0
13 7F 3	91.1	0	1952.3	0.0	38 7F 6	35.7	0	4727.0	0.0
14 7F 3	94.0	0	2017.6	0.0	39 7F 6	96.5	2	5127.0	0.0
15 7F 3	93.1	2	2043.4	0.0	40 7F 6	96.6	0	5174.6	0.0
16 7F 3	94.5	2	2069.8	0.0	41 7F 6	96.1	0	5173.9	0.0
17 7F 4	94.4	0	2744.3	0.0	42 7F 6	97.3	2	5076.1	0.0
18 7F 4	94.9	2	2717.2	0.0	43 7F 6	95.3	0	5131.0	0.0
19 7F 4	93.6	0	2691.0	0.0	44 7F 6	97.7	2	5173.2	0.0
20 7F 4	94.6	0	2414.1	0.0	45 7F 6	97.6	0	5115.3	0.0
21 7F 4	94.2	2	2481.2	0.0	46 7F 6	95.4	2	5244.3	0.0
22 7F 4	94.4	0	3083.4	0.0	47 7F 6	95.9	2	5244.8	0.0
23 7F 4	96.0	0	3117.1	0.0	48 7F 6	99.1	0	5394.3	0.0
24 7F 4	96.6	2	3151.0	0.0	49 7F 6	34.1	0	5381.5	0.0
25 7F 4	95.8	2	3211.0	0.0	50 5D 5	106.0	0	17716.7	0.0

^aSee footnote at end of table.

TABLE IX. CRYSTAL FIELD PARAMETERS, B_{km} , AND ENERGY LEVELS FOR Eu^{3+} IN YAlO_3 ^a (CONT'D)

FREE ION	PCY	PURE	2MU	THEO. ENERGY	EXP. ENERGY
51 50 1	3	130.0	2	18932.3	0.0
52 50 1	3	130.0	2	18955.3	0.0
53 50 1	3	130.0	0	18790.5	0.0
54 50 2	3	130.0	0	21391.1	0.0
55 50 2	3	130.0	0	21405.0	0.0
56 50 2	3	130.0	2	21422.0	0.0
57 50 2	3	130.0	0	21436.2	0.0
58 50 2	3	130.0	2	21454.3	0.0
59 50 3	3	130.0	0	24024.0	0.0
60 50 3	3	130.0	0	24026.2	0.0
61 50 3	3	130.0	2	24031.6	0.0
62 50 3	3	130.0	2	24038.5	0.0
63 50 3	3	130.0	0	24056.4	0.0
64 50 3	3	130.0	2	24061.2	0.0
65 50 3	3	130.0	2	24065.4	0.0

^a These B_{km} values were obtained by scaling the Ho parameters by the ϕ_k value of table II. The Ho parameters were obtained by a linear interpolation of the Dy and Er phenomenological B_{km} values.

TABLE X. CRYSTAL FIELD PARAMETERS, B_{km} , AND ENERGY LEVELS FOR Gd^{3+} IN $YAlO_3$,

SCALING FACTOR FROM $4f^7$ DETERMINED BY AVERAGING DY AND ER POWERED RESULTS									
INIT. B _{km} AND CALCULUS. Q = 0.001									
516.000 = 873		-104.000 = 842		-531.000 = 842		366.000 = 842		-38.000 = 844	
-355.000 = 866		-611.000 = 862		-225.000 = 862		-47.000 = 864		-244.000 = 866	
FREE ION	PCT PURE	2MU	THEO.-ENERGY	EXP.-ENERGY	FREE ION	PCT PURE	2MU	THEO.-ENERGY	EXP.-ENERGY
1 85 7/2	100.0	1	100.0	100.0	23 611/2	47.4	1	344.000	344.000
2 85 7/2	100.0	1	100.0	100.0	24 611/2	47.4	1	344.000	344.000
3 85 7/2	100.0	1	100.0	100.0	25 611/2	47.4	1	344.000	344.000
4 85 7/2	100.0	1	100.0	100.0	26 611/2	47.4	1	344.000	344.000
5 6P 7/2	47.4	1	32117.3	32117.3	27 611/2	47.4	1	344.000	344.000
6 6P 7/2	47.4	1	32117.3	32117.3	28 611/2	47.4	1	344.000	344.000
7 6P 7/2	47.4	1	32117.3	32117.3	29 611/2	47.4	1	344.000	344.000
8 6P 7/2	47.4	1	32117.3	32117.3	30 611/2	47.4	1	344.000	344.000
9 6P 5/2	47.4	1	32117.3	32117.3	31 611/2	47.4	1	344.000	344.000
10 6P 5/2	47.4	1	32117.3	32117.3	32 611/2	47.4	1	344.000	344.000
11 6P 5/2	47.4	1	32117.3	32117.3	33 611/2	47.4	1	344.000	344.000
12 6P 3/2	47.4	1	32117.3	32117.3	34 611/2	47.4	1	344.000	344.000
13 6P 3/2	47.4	1	32117.3	32117.3	35 611/2	47.4	1	344.000	344.000
14 61 7/2	47.4	1	32117.3	32117.3	36 611/2	47.4	1	344.000	344.000
15 61 7/2	47.4	1	32117.3	32117.3	37 611/2	47.4	1	344.000	344.000
16 61 7/2	47.4	1	32117.3	32117.3	38 611/2	47.4	1	344.000	344.000
17 61 7/2	47.4	1	32117.3	32117.3	39 611/2	47.4	1	344.000	344.000
18 61 4/2	47.4	1	32117.3	32117.3	40 611/2	47.4	1	344.000	344.000
19 61 4/2	47.4	1	32117.3	32117.3	41 611/2	47.4	1	344.000	344.000
20 61 4/2	47.4	1	32117.3	32117.3	42 611/2	47.4	1	344.000	344.000
21 61 4/2	47.4	1	32117.3	32117.3	43 611/2	47.4	1	344.000	344.000
22 61 4/2	47.4	1	32117.3	32117.3	44 611/2	47.4	1	344.000	344.000

^aThese B_{km} values were obtained by scaling the Ho parameters by the ρ_k value of table II. The Ho parameters were obtained by a linear interpolation of the Dy and Er phenomenological B_{km} values.

^a The least rms deviation between the calculated and experimental energy levels is 7.521 cm^{-1} .

IB IN VALU RUSSIAN DATA 7 MULTIPLE 4/12/75 PCME NO. 5									
FINAL REM REMEASUREMENTS: Q = 7.521									
267.335 = R23 -233.157 = S22 -106C.235 = R40 -217.466 = R42 -271.466 = 144 -6A.510 = B44									
-751.000 = R60 -317.604 = R42 -424.088 = R62 740.3175 = R64 -506.102 = R64 -221.503 = S66 21.303 = B66									
7F 6	303.2								
7F 5	2322.9								
7F 4	3560.1								
7F 3	4601.4								
7F 2	5224.7								
7F 1	5433.6								
7F 0	5639.3								
ISO 4	20629.3								
FREE ION	PCY PURE	2MU	THEO.ENERGY	EXP.ENERGY					
1 7F 6	31.2	0	-6.7	-0.0					
2 7F 6	32.6	0	-1.7	-0.0					
3 7F 6	98.7	2	151.0	-0.0					
4 7F 6	93.1	0	189.2	-0.0					
5 7F 6	34.1	2	189.6	-0.0					
6 7F 6	32.1	2	-56.1	-0.0					
7 7F 6	32.3	0	271.3	-0.0					
8 7F 6	32.3	2	475.0	-0.0					
9 7F 6	32.1	0	362.4	-0.0					
10 7F 6	32.1	0	334.4	-0.0					
11 7F 6	32.2	2	621.4	-0.0					
12 7F 6	32.1	0	454.1	-0.0					
13 7F 6	32.2	2	462.2	-0.0					
14 7F 5	94.0	2	2114.5	2126.0					
15 7F 5	93.0	2	2163.7	2168.0					
16 7F 5	32.4	0	2149.1	2182.0					
17 7F 5	32.3	0	2222.9	2219.0					
18 7F 5	32.2	0	2267.1	2266.0					
19 7F 5	32.1	2	2267.3	2266.0					
20 7F 5	32.2	2	2276.2	2273.0					
21 7F 5	91.2	0	2374.0	-0.0					
22 7F 5	91.2	0	2377.7	-0.0					
23 7F 5	91.4	2	2434.4	2434.0					
24 7F 5	91.6	0	2415.2	2431.0					

TABLE XII. CRYSTAL FIELD PARAMETERS, B_{km} , AND ENERGY LEVELS FOR Tb^{3+} IN $YAlO_3$ ^a

YB IN VAL03. SCALED B _{2M} FROM B ₂ DETERMINED BY AVERAGING DY AND EP WGMED RESULTS									
INIT. B _{2M} AND CENTEREDS. 0 = -C ₂₀₀									
536.000 = 820 -164.000 = 672 -915.000 = 840 -512.000 = 842 353.000 = 842 -36.000 = 844 -592.000 = 866									
-904.000 = 862 -47.000 = 862 -713.000 = 862 657.000 = 864 -44.000 = 864 -231.000 = 866 151.000 = 866									
TF	6	310.0	310.0	310.0	310.0	310.0	310.0	310.0	310.0
TF 5	2347.0	2347.0	2347.0	2347.0	2347.0	2347.0	2347.0	2347.0	2347.0
TF 4	3580.0	3580.0	3580.0	3580.0	3580.0	3580.0	3580.0	3580.0	3580.0
TF 3	4573.0	4573.0	4573.0	4573.0	4573.0	4573.0	4573.0	4573.0	4573.0
TF 2	5155.0	5155.0	5155.0	5155.0	5155.0	5155.0	5155.0	5155.0	5155.0
TF 1	5432.0	5432.0	5432.0	5432.0	5432.0	5432.0	5432.0	5432.0	5432.0
TF 0	5766.0	5766.0	5766.0	5766.0	5766.0	5766.0	5766.0	5766.0	5766.0
50 4	3	20569.0	20569.0	20569.0	20569.0	20569.0	20569.0	20569.0	20569.0
50 4	3	26357.0	26357.0	26357.0	26357.0	26357.0	26357.0	26357.0	26357.0
FREE ION	PCI	PURE	2MU	THEO-ENERGY	EXP-ENERGY	2MU	THEO-ENERGY	EXP-ENERGY	2MU
1 TF 6	39.7	0	0.0	38.2	25 TF 4	39.7	0	0.0	
2 TF 6	39.7	0	0.0	38.2	26 TF 4	39.7	0	0.0	
3 TF 6	39.7	0	0.0	38.2	27 TF 4	39.7	0	0.0	
4 TF 6	39.7	0	0.0	38.2	28 TF 4	39.7	0	0.0	
5 TF 6	39.7	0	0.0	38.2	29 TF 4	39.7	0	0.0	
6 TF 6	39.7	0	0.0	38.2	30 TF 4	39.7	0	0.0	
7 TF 6	39.7	0	0.0	38.2	31 TF 4	39.7	0	0.0	
8 TF 6	39.7	0	0.0	38.2	32 TF 4	39.7	0	0.0	
9 TF 5	39.7	0	0.0	38.2	33 TF 4	39.7	0	0.0	
10 TF 6	39.7	0	0.0	38.2	34 TF 3	39.7	0	0.0	
11 TF 6	39.7	0	0.0	38.2	35 TF 3	39.7	0	0.0	
12 TF 6	39.7	0	0.0	38.2	36 TF 3	39.7	0	0.0	
13 TF 6	39.7	0	0.0	38.2	37 TF 3	39.7	0	0.0	
14 TF 5	39.7	0	0.0	38.2	38 TF 3	39.7	0	0.0	
15 TF 5	39.7	0	0.0	38.2	39 TF 3	39.7	0	0.0	
16 TF 5	39.7	0	0.0	38.2	40 TF 3	39.7	0	0.0	
17 TF 5	39.7	0	0.0	38.2	41 TF 2	39.7	0	0.0	
18 TF 5	39.7	0	0.0	38.2	42 TF 2	39.7	0	0.0	
19 TF 5	39.7	0	0.0	38.2	43 TF 2	39.7	0	0.0	
20 TF 5	39.7	0	0.0	38.2	44 TF 2	39.7	0	0.0	
21 TF 5	39.7	0	0.0	38.2	45 TF 2	39.7	0	0.0	
22 TF 5	39.7	0	0.0	38.2	46 TF 2	39.7	0	0.0	
23 TF 5	39.7	0	0.0	38.2	47 TF 2	39.7	0	0.0	
24 TF 5	39.7	0	0.0	38.2	48 TF 2	39.7	0	0.0	

^a See footnote at end of table.

TABLE XII. CRYSTAL FIELD PARAMETERS, B_{km} , AND ENERGY LEVELS FOR Tb^{3+} IN $YAlO_3$ ^a (CONT'D)

	FREE ION	PCT PURE	2Mμ	THEO. ENERGY	EXP. ENERGY
46	7F 1	94.3	0	5407.1	0.0
47	7F 1	92.9	2	5491.9	0.0
48	7F 1	96.5	2	5573.3	0.0
49	7F 0	95.0	0	5420.4	0.0
50	5D 4	100.0	2	20515.7	0.0
51	5D 4	100.0	0	20722.6	0.0
52	5D 4	100.0	2	20574.3	0.0
53	5D 4	100.0	0	20534.4	0.0
54	5D 4	100.0	0	20562.0	0.0
55	5D 4	100.0	2	20592.1	0.0
56	5D 4	100.0	0	20615.7	0.0
57	5D 4	100.0	0	20620.9	0.0
58	5D 4	100.0	2	20624.6	0.0
59	5D 3	100.0	2	26334.4	0.0
60	5D 3	100.0	2	26347.2	0.0
61	5D 3	100.0	2	26354.6	0.0
62	5D 3	100.0	0	26357.7	0.0
63	5D 3	100.0	0	26361.6	0.0
64	5D 3	100.0	2	26365.1	0.0
65	5D 3	100.0	0	26373.7	0.0

^aThese B_{km} values were obtained by scaling the Ho parameters by the ρ_k value of table II. The Ho parameters were obtained by a linear interpolation of the D_J and E_r phenomenological B_{km} values.

TABLE VIII
ENERGY LEVELS AND PHENOMENOLOGICAL CRYSTAL FIELD PARAMETERS FOR Dv^{3+} IN $YAlO_3$ ^a

[illegible]

a The least-rms deviation between the calculated and experimental energy levels is 8.010 cm^{-1} .

TABLE XV. ENERGY LEVELS AND PHENOMENOLOGICAL CRYSTAL FIELD PARAMETERS FOR Ho^{3+} IN YAlO_3 ^a

HO IN VALD RUSSIAN DATA				9/18/75		MUNE NO. 6	
FINAL S.M. AND CENTRICITY				C = 7.033			
710.337 = 020				-747.138 = 822		-817.569 = 840	
-963.432 = 860				211.439 = 862		-213.585 = 862	
51 8	292.1	99.9	2	-2.1	0.0	33 51 0	844
51 7	5267.3	99.9	2	6.2	-0.0	34 51 0	844
51 6	6735.9	99.9	0	41.1	44.0	35 51 6	844
51 5	11243.7	99.9	0	67.1	65.0	36 51 0	844
1 51 6		99.9	2	110.6	-0.0	37 51 0	844
2 51 4		99.9	0	161.4	155.0	38 51 6	844
3 51 8		99.9	0	191.7	186.0	39 51 6	844
4 51 8		99.9	0	233.7	236.0	40 51 6	844
5 51 8		99.9	2	264.1	-0.0	41 51 6	844
6 51 8		99.9	0	325.6	330.0	42 51 6	844
7 51 8		99.9	0	392.2	380.0	43 51 6	844
8 51 8		99.9	2	404.9	405.0	44 51 6	844
9 51 8		99.9	0	443.4	-0.0	45 51 6	844
10 51 8		99.9	2	540.4	-0.0	46 51 6	844
11 51 8		99.9	0	516.1	-0.0	47 51 6	844
12 51 8		99.9	0	618.9	-0.0	48 51 6	844
13 51 8		99.9	2	614.3	-0.0	49 51 6	844
14 51 8		99.9	0	516.1	-0.0	50 51 6	844
15 51 8		99.9	0	516.1	-0.0	51 51 6	844
16 51 8		99.9	0	516.1	-0.0	52 51 6	844
17 51 8		99.9	2	516.1	-0.0	53 51 6	844
18 51 7		99.9	0	516.1	-0.0	54 51 6	844
19 51 7		99.9	0	516.1	-0.0	55 51 6	844
20 51 7		99.9	2	516.1	-0.0	56 51 6	844
21 51 7		99.9	0	516.1	-0.0	57 51 6	844
22 51 7		99.9	0	516.1	-0.0	58 51 6	844
23 51 7		99.9	2	516.1	-0.0	59 51 6	844
24 51 7		99.9	0	516.1	-0.0	60 51 6	844
25 51 7		99.9	0	516.1	-0.0	61 51 6	844
26 51 7		99.9	2	516.1	-0.0	62 51 6	844
27 51 7		99.9	0	516.1	-0.0	63 51 6	844
28 51 7		99.9	2	516.1	-0.0	64 51 6	844
29 51 7		99.9	0	516.1	-0.0	65 51 6	844
30 51 7		99.9	0	516.1	-0.0	66 51 6	844
31 51 7		99.9	0	516.1	-0.0	67 51 6	844
32 51 7		99.9	2	516.1	-0.0	68 51 6	844

^aThe least-rms deviation between the calculated and experimental energy levels is 7.033 cm^{-1} .

TABLE XVI. CRYSTAL FIELD PARAMETERS, B_{km} , AND ENERGY LEVELS FOR Ho^{3+} IN $YAlO_3$ ^a

WD IN VALU3. SCALED BHM FROM HQ DETERMINED BY AVERAGING DY AND ER MOPED RESULTS									
INIT. BHM AND CENTRIGS. Q = 0.003									
542.000 = B23		-166.000 = B22		-866.000 = B40		-481.000 = B42		332.000 = B62	
-815.000 = B60		-42.000 = B62		-192.000 = B62		592.000 = P64		-40.000 = B64	
51 8		169.6							
51 7		5219.5							
51 6		8717.6							
51 5		11274.7							
51 4		13333.4							
		FREE ION		PCT PURE		2MU		THEO.ENERGY EXP.ENERGY	
1 51 8	99.9	2	-92.1	0.0	33 51 6	32.6	9643.2	0	0.0
2 51 8	99.9	2	-84.4	0.0	34 51 6	32.6	8649.0	0	0.0
3 51 8	100.0	0	-43.5	0.0	35 51 6	99.7	8653.5	2	0.0
4 51 8	99.9	1	-27.1	0.0	36 51 6	93.7	8670.4	2	0.0
5 51 8	99.9	2	51.3	0.0	37 51 6	32.6	8588.6	0	0.0
6 51 8	100.0	0	72.3	0.0	38 51 6	32.6	8673.7	0	0.0
7 51 8	99.9	2	147.3	0.0	39 51 6	32.4	8696.3	2	0.0
8 51 8	100.0	0	177.8	0.0	40 51 6	99.4	8709.5	0	0.0
9 51 8	99.9	2	180.6	0.0	41 51 6	32.6	8726.3	0	0.0
10 51 8	100.0	0	212.1	0.0	42 51 6	99.7	8775.3	0	0.0
11 51 8	100.0	2	216.5	0.0	43 51 6	99.7	8783.2	2	0.0
12 51 8	100.0	0	239.2	0.0	44 51 6	99.9	8809.4	2	0.0
13 51 8	99.9	0	302.2	0.0	45 51 6	32.7	8803.9	0	0.0
14 51 8	99.9	2	322.0	0.0	46 51 5	98.9	11210.7	2	0.0
15 51 8	99.9	0	351.5	0.0	47 51 5	32.1	11215.3	2	0.0
16 51 8	99.9	2	372.4	0.0	48 51 5	32.4	11237.0	0	0.0
17 51 8	99.9	0	380.4	0.0	49 51 5	32.4	11246.4	0	0.0
18 51 7	99.9	0	5120.6	0.0	50 51 5	32.6	11246.3	2	0.0
19 51 7	99.9	0	5125.1	0.0	51 51 5	32.1	11267.4	0	0.0
20 51 7	99.7	2	5135.0	0.0	52 51 5	32.0	11267.4	2	0.0
21 51 7	99.7	2	5140.5	0.0	53 51 5	99.3	11307.1	0	0.0
22 51 7	99.7	0	5200.1	0.0	54 51 5	99.3	11327.3	2	0.0
23 51 7	99.9	2	5211.9	0.0	55 51 5	32.7	11347.4	2	0.0
24 51 7	99.7	0	5213.8	0.0	56 51 5	32.2	11350.2	0	0.0
25 51 7	99.7	2	5225.5	0.0	57 51 4	32.4	13174.6	2	0.0
26 51 7	99.7	2	5231.4	0.0	58 51 4	32.6	13224.5	0	0.0
27 51 7	99.9	0	5235.2	0.0	59 51 4	32.6	13232.1	2	0.0
28 51 7	99.7	2	5246.4	0.0	60 51 4	32.6	13315.7	0	0.0
29 51 7	99.7	2	5285.0	0.0	61 51 4	32.7	13362.4	0	0.0
30 51 7	99.9	0	5291.6	0.0	62 51 4	32.3	13372.1	2	0.0
31 51 7	99.9	0	5301.2	0.0	63 51 4	32.1	13437.1	0	0.0
32 51 7	99.9	2	5303.2	0.0	64 51 4	32.1	13477.3	2	0.0
					65 51 4	32.7	13523.3	0	0.0

^a These B_{km} values were obtained by scaling the Ho parameters by the ρ_k value of table II. The Ho parameters were obtained by a linear interpolation of the Dy and Er phenomenological B_{km} values.

TABLE XVII. ENERGY LEVELS AND PHENOMENOLOGICAL CRYSTAL FIELD PARAMETERS FOR Er^{3+} IN YAlO_3

ER IN VALO ANIONOW'S DATA -HOFIE 9/10/78									
FINAL	BRK AND CF	Q = 15-34'S	-742.799 = 840	-497.332 = 842	391.316 = 842	-481.981 = 844	-466.019 = 844		
	546.608 = 821	-7.553 = 822	-175.200 = 862	325.166 = 864	209.931 = 864	30.178 = 866	252.958 = 866		
	-876.858 = 862	-30%.479 = 862							
4115/2	264-3								
4113/2	6737-3								
4111/2	10348-4								
41 9/2	12564-3								
4F 9/2	15368-5								
4S 3/2	18467-2								
2H11/2 2	19192-1								
4F 7/2	20581-5								
4F 5/2	22229-8								
4F 3/2	22564-5								
		FREE ION	PCT PURE	2MU	THEO.ENERGY	EXP.ENERGY			
1 4115/2	99-9	1	-10-2	0-0	27 4F 9/2	39-9	1	15266-2	15263-0
2 4115/2	100-0	1	57-8	50-C	28 4F 9/2	39-8	1	15333-5	15346-C
3 4115/2	100-0	1	168-8	170-C	29 4F 9/2	39-8	1	15372-7	15375-C
4 4115/2	100-0	1	212-4	217-C	30 4F 9/2	39-8	1	15429-6	15397-0*
5 4115/2	100-0	1	275-0	267-C	31 4F 9/2	39-9	1	15461-4	15482-C*
6 4115/2	100-C	1	376-0	369-C					
7 4115/2	100-0	1	453-9	446-C	32 4S 3/2	36-8	1	16413-9	18407-0
8 4115/2	100-0	1	528-5	525-C	33 4S 3/2	37-2	1	18486-2	18490-C
9 4113/2	99-0	1	6589-0	6608-C*	34 2H11/2 2	39-C	1	19116-5	19070-C*
10 4113/2	99-8	1	6647-8	6646-C	35 2H11/2 2	37-9	1	19139-0	19120-C*
11 4113/2	99-7	1	6690-5	6674-C*	36 2H11/2 2	39-C	1	19175-6	19163-C
12 4113/2	99-0	1	672C-8	6720-C	37 2H11/2 2	39-5	1	19211-7	19243-D*
13 4113/2	99-9	1	6773-4	6774-C	38 2H11/2 2	37-5	1	19255-2	19278-G*
14 4113/2	99-8	1	6831-5	6820-C	39 2H11/2 2	38-5	1	19281-7	19305-G*
15 4113/2	99-4	1	6871-3	6873-C	40 4F 7/2	39-3	1	20510-3	20488-C*
16 4111/2	99-7	1	10277-6	10290-C	41 4F 7/2	39-1	1	20553-3	20562-C
17 4111/2	99-7	1	10300-8	10302-C	42 4F 7/2	39-6	1	20593-2	20623-0*
18 4111/2	99-7	1	10336-4	10330-C	43 4F 7/2	39-5	1	20694-3	20691-C
19 4111/2	99-7	1	10356-5	10355-C					
20 4111/2	99-7	1	10396-1	10390-C	44 4F 5/2	39-5	1	22711-2	22701-C
21 4111/2	99-6	1	10413-4	10410-C	45 4F 5/2	39-1	1	22717-7	22733-C
22 41 9/2	99-8	1	12376-3	12387-C	46 4F 5/2	39-9	1	22772-9	22767-C
23 41 3/2	99-7	1	12458-1	12460-C*	47 4F 3/2	39-2	1	22752-9	22537-C*
24 41 3/2	99-9	1	12606-6	12617-C	48 4F 3/2	39-7	1	22762-8	22643-C*
25 41 9/2	99-7	1	12643-8	12642-C					
26 41 9/2	99-8	1	12732-5	12726-C					

^a The least-rms deviation between these calculated and experimental energy levels is 15.385 cm^{-1} (48 levels).

TABLE XVIII. ENERGY LEVELS AND PHENOMENOLOGICAL CRYSTAL FIELD PARAMETERS FOR Er^{3+} IN YAlO_3

ER 15 VALS. RUSSIAN DATA MULTIPLETS $J=15/15$

FINAL EXP AND CRYSTAL FDS. $G = 7.461$

$430.900 = 420$ $617.465 = 622$

$-742.671 = 363$ $-240.967 = 362$

$-835.695 = 840$ $-365.812 = 842$

$-1.0.313 = 862$ $536.365 = 864$

$-709.079 = 866$
 $223.613 = 866$

$365.198 = 862$
 $17.009 = 864$

$-218.279 = 844$
 $23.210 = 866$

1236.140
 12440.00

12617.00
 12642.00

12776.00
 15243.00

15340.00
 15375.00

15467.00
 15470.00

15470.00
 15470.00

15470.00
 15470.00

15470.00
 15470.00

15470.00
 15470.00

15470.00
 15470.00

15470.00
 15470.00

15470.00
 15470.00

15470.00
 15470.00

15470.00
 15470.00

15470.00
 15470.00

15470.00
 15470.00

15470.00
 15470.00

15470.00
 15470.00

15470.00
 15470.00

15470.00
 15470.00

FREE ION PCF MULT. $J=15/15$ EXP. ENERGY

$22.41 3/2$ $23.41 3/2$ $24.41 3/2$ $25.41 3/2$ $26.41 3/2$ $27.41 3/2$ $28.41 3/2$ $29.41 3/2$ $30.41 3/2$ $31.41 3/2$ $32.41 3/2$ $33.41 3/2$

0.00 50.00 170.00 217.00 267.00 319.00 373.00 429.00 486.00 544.00 603.00 663.00

663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00

663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00

663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00

663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00

663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00

663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00

663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00

663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00

663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00

663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00

663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00

663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00

663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00

663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00

663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00

663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00

663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00

663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00 663.00

BEST AVAILABLE COPY

TABLE XIX. CRYSTAL FIELD PARAMETERS, B_{km} , AND ENERGY LEVELS FOR Er^{3+} IN $YAlO_3$ ^a

ER IN VALC3. SCALED ACP FROM HQ DETERMINED BY AVERAGING DY AND FF HOMED RESULTS									
[INIT. BKM AND CENTERING. Q = -0.00]									
540.300 = 823		-161.000 = 822		-841.000 = 860		-470.000 = 862		325.000 = 864	
-791.000 = 863		-41.000 = 862		-186.000 = 862		575.000 = 864		-33.000 = 866	
-202.000 = 866		-544.000 = 866		132.000 = 866					
4115/2	265.0								
4113/2	5738.0								
4111/2	10348.0								
41 9/2	12565.0								
46 9/2	15369.0								
45 3/2	18472.0								
2411/2 2	13155.0								
46 7/2	20562.0								
46 5/2	22230.0								
46 3/2	22561.0								
		FREE IDN	PCT PURE	ZMU	THEO.-ENERGY	EXP.-ENERGY			
1 4115/2	93.9	1	0.0	0.0	27 4F 9/2	33.3	1	15271.2	0.0
2 4115/2	106.0	1	0.0	0.0	28 4F 9/2	93.4	1	15360.1	0.0
3 4115/2	106.0	1	0.0	0.0	29 4F 3/2	93.4	1	15371.3	0.0
4 4115/2	100.0	1	0.0	0.0	30 4F 9/2	93.4	1	15407.3	0.0
5 4115/2	100.0	1	0.0	0.0	31 4F 3/2	93.9	1	15475.3	0.0
6 4115/2	100.0	1	0.0	0.0	32 4S 3/2	97.3	1	18421.1	0.0
7 4115/2	100.0	1	0.0	0.0	33 4S 3/2	97.1	1	18431.3	0.0
8 4115/2	100.0	1	0.0	0.0	34 2H11/2 2	97.3	1	19112.7	0.0
9 4113/2	93.9	1	0.0	0.0	35 2H11/2 2	93.6	1	19133.0	0.0
10 4113/2	93.9	1	0.0	0.0	36 2H11/2 2	93.0	1	19183.1	0.0
11 4113/2	99.8	1	0.0	0.0	37 2H11/2 2	93.0	1	19205.6	0.0
12 4113/2	93.9	1	0.0	0.0	38 2H11/2 2	93.3	1	19242.7	0.0
13 4113/2	93.9	1	0.0	0.0	39 2H11/2 2	93.5	1	19263.5	0.0
14 4113/2	93.4	1	0.0	0.0	40 4F 1/2	93.4	1	20504.5	0.0
15 4113/2	93.9	1	0.0	0.0	41 4F 1/2	93.4	1	20557.3	0.0
16 4111/2	93.7	1	0.0	0.0	42 4F 1/2	93.4	1	20607.4	0.0
17 4111/2	93.7	1	0.0	0.0	43 4F 1/2	93.4	1	20694.5	0.0
18 4111/2	93.8	1	0.0	0.0	44 4F 5/2	93.2	1	22211.5	0.0
19 4111/2	93.6	1	0.0	0.0	45 4F 5/2	93.7	1	22217.7	0.0
20 4111/2	93.7	1	0.0	0.0	46 4F 5/2	93.4	1	22274.1	0.0
21 4111/2	93.7	1	0.0	0.0	47 4F 3/2	93.2	1	22531.4	0.0
22 41 9/2	93.6	1	0.0	0.0	48 4F 3/2	93.2	1	22625.2	0.0
23 41 3/2	93.4	1	0.0	0.0					
24 41 9/2	93.2	1	0.0	0.0					
25 41 3/2	93.4	1	0.0	0.0					
26 41 3/2	93.4	1	0.0	0.0					

^a These B_{km} values were obtained by scaling the B_0 parameters by the ρ_k value of table II. The B_0 parameters were obtained by a linear interpolation of the Dy and Er phenomenological B_{km} values.

TABLE XX. ENERGY LEVELS AND PHENOMENOLOGICAL CRYSTAL FIELD PARAMETERS FOR Tm^{3+} IN $YAlO_3$ ^a

TP IN VALG RUSSIAN DATA 9/17/75									
FINAL BRP AND CENTRIFUGAL Q = 6.16									
675.19P = 820									
-75.502 = 672									
-71.536 = 852									
-752.332 = 860									
3M 6	342.0								
3F 4	5862.8								
3M 5	8485.7								
3F 1	14546.4								
3F 2	15145.3								
1G 4	21343.5								
FREE ION PCT PUNE 2MU THEO-ENERGY EXP-ENERGY									
1 3M 6	73.9	2	2.0		29 3M 5	73.0	2	1537.0	-0.0
2 3M 6	73.9	0	3.1		30 3M 5	73.5	0	1537.3	1456.0*
3 3M 6	73.9	2	11.7		31 3M 5	73.5	0	1537.1	-0.0
4 3M 6	73.9	0	13.2		32 3M 5	73.7	2	1537.1	-0.0
5 3M 6	73.9	0	23.2		33 3M 5	73.9	2	1537.4	1456.0
6 3M 6	100.0	2	34.0						
7 3M 6	100.0	2	35.4		34 3F 3	73.0	2	14465.2	14454.0*
8 3M 6	73.9	0	40.3		35 3F 3	73.9	2	14491.3	14483.0*
9 3M 6	73.9	0	46.5		36 3F 3	73.4	0	14523.8	14512.0
10 3M 6	100.0	2	47.2		37 3F 3	73.4	2	14544.4	14535.0*
11 3M 6	73.9	2	53.9		38 3F 3	73.7	2	14571.1	14565.0*
12 3M 6	100.0	0	59.7		39 3F 3	73.1	0	14616.7	14609.0
13 3M 6	100.0	0	62.5		40 3F 3	73.4	0	14627.0	14624.0
14 3F 4	73.7	0	562.4		41 3F 2	73.3	2	15345.6	-0.0
15 3F 4	73.4	0	571.4		42 3F 2	73.6	0	15127.4	-0.0
16 3F 4	73.1	0	578.6		43 3F 2	73.7	2	15134.1	-0.0
17 3F 4	73.7	0	582.2		44 3F 2	73.0	2	15197.3	15187.0
18 3F 4	73.4	2	583.4		45 3F 2	73.1	0	15340.4	15332.0
19 3F 4	73.5	0	586.1		46 1G 4	145.7	2	21372.3	21365.0
20 3F 4	73.7	0	586.5		47 1G 4	145.7	2	21372.3	21365.0
21 3F 4	73.5	2	586.5		48 1G 4	145.7	2	21372.3	21365.0
22 3F 4	73.5	2	613.4		49 1G 4	145.7	2	21372.3	21365.0
23 3H 5	73.6	0	637.3		50 1G 4	145.7	2	21372.3	21365.0
24 3H 5	73.7	2	637.3		51 1G 4	145.7	2	21372.3	21365.0
25 3H 5	73.6	2	637.3		52 1G 4	145.7	2	21372.3	21365.0
26 3H 5	73.5	0	637.3		53 1G 4	145.7	2	21372.3	21365.0
27 3H 5	73.7	0	644.3		54 1G 4	145.7	2	21372.3	21365.0
28 3H 5	73.5	2	644.3						

^a The least-rms deviation between the calculated and experimental energy levels is 6.16 cm^{-1} .

TABLE XXI. CRYSTAL FIELD PARAMETERS, B_{km} , AND ENERGY LEVELS FOR Tm^{3+} IN $YAlO_3$ ^a

FM IN VAL03. SCALED FROM HQ DETERMINED BY AVERAGING OY AND EP WOPED RESULTS									
INIT. BXP AND CENTRICIDS. Q = -0.020									
552.000 = 920 -169.000 = 842 -626.000 = 842 319.000 = 842 -33.000 = 844 -535.000 = 844									
-778.000 = 860 -40.000 = 862 -183.000 = 864 565.000 = 864 -196.000 = 866 190.000 = 866									
3M 6	255.0	3M 4	5820.0	3M 5	8435.0	3M 4	12731.0	3F 3	14529.0
3F 2	15133.0	1G 4	21325.0	1D 2	27892.0				
FREE ION PCT PURE 2PU IMED. ENERGY EXP. ENERGY									
1 3M 4	93.3	0	-74.2	29 3M 5	99.6	2	6473.8	7.0	
2 3M 6	93.3	2	-68.8	30 3M 5	91.5	0	8553.1	0.0	
3 3M 6	99.9	2	31.4	31 3M 5	99.6	0	8573.2	0.0	
4 3M 6	100.0	0	53.7	32 3M 5	99.7	2	8617.1	0.0	
5 3M 6	93.8	0	202.6	33 3M 5	92.9	2	8631.3	0.0	
6 3M 6	100.0	2	242.6						
7 3M 6	99.9	2	292.7	34 3M 4	91.5	0	12450.0	0.0	
8 3M 6	99.9	0	423.2	35 3M 4	98.8	2	12570.1	0.0	
9 3M 6	99.6	0	452.3	36 3M 4	92.6	2	12652.4	0.0	
10 3M 6	99.9	2	392.4	37 3M 4	98.8	0	12691.9	0.0	
11 3M 6	99.3	2	450.3	38 3M 4	98.8	2	12745.4	0.0	
12 3M 6	99.9	0	484.7	39 3M 4	93.2	2	12765.0	0.0	
13 3M 6	99.9	0	503.9	40 3M 4	93.6	0	12800.9	0.0	
14 3F 4	93.7	0	5282.2	41 3M 4	99.6	0	12885.4	0.0	
15 3F 4	93.4	2	5664.3	42 3M 4	93.3	0	12932.5	0.0	
16 3F 4	93.2	0	5690.1	43 3F 3	98.8	2	14470.9	0.0	
17 3F 4	93.6	0	5777.5	44 3F 3	93.7	2	14534.7	0.0	
18 3F 4	93.4	2	5840.9	45 3F 3	97.3	0	14576.6	0.0	
19 3F 4	99.6	0	5893.5	46 3F 3	94.3	2	14582.4	0.0	
20 3F 4	93.7	0	5925.2	47 3F 3	94.7	2	14600.3	0.0	
21 3F 4	93.5	2	5956.3	48 3F 3	91.6	0	14611.3	0.0	
22 3F 4	93.7	2	6002.3	49 3F 3	97.3	0	14614.6	0.0	
23 3M 5	93.6	0	8197.3						
24 3M 5	93.6	2	8214.7						
25 3M 5	99.6	2	8290.6						
26 3M 5	93.5	0	8331.1						
27 3M 5	99.3	0	8440.6						
28 3M 5	99.3	2	8460.6						

^a See footnote at end of table.

TABLE XXI. CRYSTAL FIELD PARAMETERS, B_{km} , AND ENERGY LEVELS
FOR Tm^{3+} IN $YAlO_3$ (CONT'D)

	FREE ION	PCT PURE	ZMU	THEO. ENERGY	EXP. ENERGY
50	3F 2	94.9	0	15165.3	0.0
51	3F 2	94.9	2	15134.5	0.0
52	3F 2	94.9	2	15147.0	0.0
53	3F 2	94.9	2	15169.5	0.0
54	3F 2	94.9	0	15175.4	0.0
55	1G 4	94.9	0	21021.0	0.0
56	1G 4	94.9	2	21107.4	0.0
57	1G 4	94.9	2	21195.0	0.0
58	1G 4	100.0	2	21104.3	0.0
59	1G 4	100.0	2	21274.5	0.0
60	1G 4	100.0	0	21274.5	0.0
61	1G 4	100.0	2	21587.4	0.0
62	1G 4	100.0	2	21587.4	0.0
63	1G 4	100.0	2	21587.4	0.0
64	1G 2	99.9	0	27402.2	0.0
65	1G 2	99.9	0	27402.2	0.0
66	1G 2	100.0	2	27407.9	0.0
67	1G 2	100.0	2	27463.5	0.0
68	1G 2	100.0	2	27463.5	0.0

^a These B_{km} values were obtained by scaling the H_0 parameters by the ρ_k value of table II. The H_0 parameters were obtained by a linear interpolation of the Dy and Er phenomenological B_{km} values.

A_{km} IN cm^{-1} A-k, OF SPHERICAL DECOMPOSITION OF YAIO_3 LATTICE SUMS^a

z	μ	$A_{\text{core}}(z)_{\text{core}}^{\text{core}}$	$1 - A_{\text{core}}(z)_{\text{core}}^{\text{core}}$	$A_{\text{core}}(z)_{\text{core}}^{\text{core}}$	$1 - A_{\text{core}}(z)_{\text{core}}^{\text{core}}$
0	0	-8411.2		16.22	
0	1	1203		0.004	
0	2	68.117		816.8	
0	3	-444.7		725.7	
0	4	-1834		-1183	
0	5	-1025		-1125	
0	6	336.2		3230	
0	7	-471.3		-627.0	
0	8	-1976		-3918	
0	9	1994		419.6	
0	10	-659.1		-1231	
0	11	1462		824.2	
0	12	-812.3		-1553	
0	13	-329.8		-779.6	
0	14	53.93		128.1	
0	15	-272.2		-932.3	
0	16	-1321		-2673	
0	17	794.9		1815	
0	18	-738.4		-1751	
0	19	12.35		60.47	
0	20	-231.1		-554.4	
0	21	110.3		224.5	
0	22	435.9		1066	
0	23	121.9		243.6	
0	24	-282.9		-719.6	
0	25	15.18		30.56	
0	26	-160.1		-309.7	
0	27	-72.75		-146.5	
0	28	-26.31		-58.64	
0	29	13.50		27.87	
0	30	15.48		39.00	
0	31	-27.56		-55.06	
0	32	-21.40		-42.37	

$\mathcal{A}_{\text{non}}^{\text{non}} = \{A \in \mathcal{A} \mid \text{non}(A) = 1\}$ and $\mathcal{A}_{\text{non}}^{\text{non}} = \{A \in \mathcal{A} \mid \text{non}(A) = 1\}$.
 Since $\mathcal{A}_{\text{non}}^{\text{non}} = \{A \in \mathcal{A} \mid \text{non}(A) = 1\}$, then the non-trivial
 $\mathcal{A}_{\text{non}}^{\text{non}} = \{A \in \mathcal{A} \mid \text{non}(A) = 1\}$ and $\mathcal{A}_{\text{non}}^{\text{non}} = \{A \in \mathcal{A} \mid \text{non}(A) = 1\}$.

[illegible]

Atom	γ 1 ⁺	Δ 1 ⁺	σ 1 ⁺	σ 1 ⁺
Position	h_{1c}	h_{1b}	h_{1c}	h_{1d}
α	0.0526(2)	0	0.475(2)	0.293(2)
γ	0.025	0	0.025	0.044(2)
δ	0.9896(2)	0.050	0.086(2)	0.703(2)

TABLE XXIII. AMPLITUDES, CRYSTAL FIELD COMPONENTS, A_{km} IN $\text{cm}^{-1} \text{ \AA}^{-k}$, OF SPHERICAL DECOMPOSITION OF YAlO_3 LATTICE SUMS FOR EVEN VALUES OF k^2

k	m	$A_{km} (a_0) = 1$		$A_{km} (a_0) = -1.5$	
		Real	Imaginary	Real	Imaginary
2	0	2365.1	0	3482	0
2	1	0	-384.5	0	-466.2
2	2	610.3	0	615.4	0
4	0	-1749	0	-3321	0
4	1	0	1401	0	2108
4	2	698.2	0	1007	0
4	3	0	860.0	0	1274
4	4	-779.5	0	167.3	0
6	0	-285.6	0	-502.2	0
6	1	0	36.68	0	62.44
6	2	-67.11	0	-101.0	0
6	3	0	94.78	0	146.2
6	4	739.6	0	125.9	0
6	5	0	-52.15	0	-77.24
6	6	137.8	0	204.2	0

^aThe coordinate system has been rotated so that the real part of $A_{km} = 0$ for $m \neq 0$. The lattice constants and atomic positions are given in Table XXII.

LITERATURE CITED

- (1) M. Bass and M. J. Weber, *Laser Focus*, 7 (1971), 34-36.
- (2) M. J. Weber and T. E. Varitimos, *J. Appl. Phys.*, 42 (1971), 4996-5005.
- (3) Kh. S. Bagdasarov, A. A. Kaminskii, and G. I. Rogov, *Sov. Phys. Doklady*, 14 (1969), 346-348.
- (4) J. L. Berg, High Resolution Low Temperature Spectra of Tb³⁺ in YAlO₃, Master's Thesis, Air Force Institute of Technology, Wright-Patterson Air Force Base, OH (June 1973).
- (5) V. A. Antanov, P. A. Arsenev, K. E. Bienert, and A. V. Potemkin, *Phys. Status Solidi A*, 19 (1973), 289-299.
- (6) V. L. Donlan and A. A. Santiago, Jr., *J. Chem. Phys.*, 57 (1972), 4717-4723.
- (7) D. E. Wortman, C. A. Morrison, and N. Karayianis, Rare Earth Ion-Host Lattice Interactions 11. Lanthanides in Y₃Al₅O₁₂, Harry Diamond Laboratories TR-1773 (August 1976).
- (8) R. Diehl and G. Brandt, *Materia Research Bulletin*, 10 (1975), 85-90.
- (9) W. T. Carnall, P. R. Fields, and K. Rajnak, *J. Chem. Phys.*, 49 (1968), 4412-4455.
- (10) C. A. Morrison, D. E. Wortman, and N. Karayianis, *J. Phys. C: Solid State Phys.*, 9 (1976), L191.
- (11) A. J. Freeman and R. E. Watson, *Phys. Rev.*, 127 (1962), 2058-2075.
- (12) P. Erdos and J. H. Kang, *Phys. Rev. B*, 6 (1972), 3393-3408.
- (13) R. P. Leavitt, C. A. Morrison, and D. E. Wortman, Rare Earth Ion-Host Crystal Interactions 3. Three-Parameter Theory of Crystal Fields, Harry Diamond Laboratories TR-1673 (June 1975).
- (14) N. Karayianis and C. A. Morrison, Rare Earth Ion-Host Lattice Interactions 1. Point Charge Lattice Sum in Scheelites, Harry Diamond Laboratories TR-1648 (October 1973).
- (15) N. Karayianis, D. E. Wortman, and C. A. Morrison, *Solid State Comm.*, 18 (1976).

DISTRIBUTION

DEFENSE DOCUMENTATION CENTER
CAMERON STATION, BUILDING 5
ALEXANDRIA, VA 22314
ATTN DDC-TCA (12 COPIES)

COMMANDER
USA RSCH & STD GP (EUR)
BOX 65
FPO NEW YORK 09510
ATTN LTC JAMES M. KENNEDY, JR.
CHIEF, PHYSICS & MATH BRANCH

COMMANDER
US ARMY MATERIEL DEVELOPMENT
& READINESS COMMAND
5001 EISENHOWER AVENUE
ALEXANDRIA, VA 22333
ATTN DRXAM-TL, HQ TECH LIBRARY
ATTN DRUDE, DIR FOR DEV & ENGR

COMMANDER
USA ARMAMENT COMMAND
ROCK ISLAND, IL 61201
ATTN DRXAR-ASF, FUZE DIV
ATTN DRXAR-RDF, SYS DEV DIV - FUZES

COMMANDER
USA MISSILE & MUNITIONS CENTER
& SCHOOL
REDSTONE ARSENAL, AL 35809
ATTN ATSK-CTD-F

DIRECTOR
DEFENSE NUCLEAR AGENCY
WASHINGTON, DC 20305
ATTN APTEL, TECH LIBRARY

DIRECTOR OF DEFENSE RES AND
ENGINEERING
WASHINGTON, DC 20301
ATTN TECHNICAL LIBRARY (3C128)

OFFICE, CHIEF OF RESEARCH,
DEVELOPMENT, & ACQUISITION
DEPARTMENT OF THE ARMY
WASHINGTON, DC 20210
ATTN DAMA-ARZ-A, CHIEF SCIENTIST
DR. M. E. LASSER
ATTN DAMA-ARZ-B, DR. I. R. HERSHNER

COMMANDER
US ARMY RESEARCH OFFICE (DURHAM)
PO BOX 12211
RESEARCH TRIANGLE PARK, NC 27709
ATTN DR. ROBERT J. LONTZ
ATTN DR. CHARLES BOGOSIAN

COMMANDER
ARMY MATERIALS & MECHANICS RESEARCH
CENTER
WATERTOWN, MA 02172
ATTN DRXMR-TL, TECH LIBRARY BR

COMMANDER
NATICK LABORATORIES
NATICK, MA 01762
ATTN DRXRES-RTL, TECH LIBRARY

COMMANDER
USA FOREIGN SCIENCE & TECHNOLOGY CENTER
FEDERAL OFFICE BUILDING
220 7TH STREET NE
CHARLOTTESVILLE, VA 22901
ATTN DRXST-BE, BASIC SCIENCE DIV

DIRECTOR
USA BALLISTICS RESEARCH LABORATORIES
ABERDEEN PROVING GROUND, MD 21005
ATTN DRXBR, DIRECTOR, R. MICHELBERGER
ATTN DRXBR-TB, FRANK J. ALLEN
ATTN DRXBR, TECH LIBRARY

COMMANDER
USA ELECTRONICS COMMAND
FORT MONMOUTH, NJ 07703
ATTN DRSEL-GG, TECHNICAL LIBRARY
ATTN DRSEL-CT-L, B. LOUIS
ATTN DRSEL-CT-L, DR. E. SCHIEL
ATTN DRSEL-CT-L, DR. HIESLMAN
ATTN DRSEL-CT-L, J. STROZYK
ATTN DRSEL-CT-L, DR. E. J. TEBO
ATTN DRSEL-CT-L, DR. R. G. BUSER
ATTN DRSEL-WL-S, J. CHARLTON

COMMANDER
USA ELECTRONICS COMMAND
FORT BELVOIR, VA 22060
ATTN DRSEL-NV, NIGHT VISION LABORATORY
ATTN DRSEL-NV, LIBRARY

COMMANDER
USA ELECTRONICS COMMAND
WHITE SANDS MISSILE RANGE, NM 88002
ATTN DRSEL-BL, LIBRARY

DIRECTOR
DEFENSE COMMUNICATIONS ENGINEER CENTER
1860 WIEHLE AVE
RESTON, VA 22090
ATTN PETER A. VENA

DISTRIBUTION (Cont'd)

COMMANDER
USA MISSILE COMMAND
REDSTONE ARSENAL, AL 35809
ATTN DRSMI-RB, REDSTONE SCIENTIFIC
INFO CENTER
ATTN DRSMI-RR, DR. J. P. HALLOWES
ATTN DRCPM-HEL, W. B. JENNINGS
ATTN DRSMI-RR, T. HONEYCUTT

COMMANDER
EDGEWOOD ARSENAL
EDGEWOOD ARSENAL, MD 21010
ATTN SAREA-TS-L, TECH LIBRARY

COMMANDER
FRANKFORD ARSENAL
BRIDGE & TACONY STREETS
PHILADELPHIA, PA 19137
ATTN K1000, TECH LIBRARY

COMMANDER
PICATINNY ARSENAL
DOVER, NJ 07801
ATTN SARPA-TS-T-S, TECH LIBRARY

COMMANDER
USA TEST & EVALUATION COMMAND
ABERDEEN PROVING GROUND, MD 21005
ATTN TECH LIBRARY

COMMANDER
USA ABERDEEN PROVING GROUND
ABERDEEN PROVING GROUND, MD 21005
ATTN STEAP-TL, TECH LIBRARY, BLDG 305

COMMANDER
WHITE SANDS MISSILE RANGE, NM 88002
ATTN DRSEL-WL-MS, ROBERT NELSON

COMMANDER
GENERAL THOMAS J. RODMAN LABORATORY
ROCK ISLAND ARSENAL
ROCK ISLAND, IL 61201
ATTN SWERR-PL, TECH LIBRARY

COMMANDER
USA CHEMICAL CENTER & SCHOOL
FORT MC CLELLAN, AL 36201

COMMANDER
NAVAL ELECTRONICS LABORATORY CENTER
SAN DIEGO, CA 92152
ATTN TECH LIBRARY

COMMANDER
NAVAL SURFACE WEAPONS CENTER
WHITE OAK, MD 20910
ATTN CODE 730, LIBRARY DIV

DIRECTOR
NAVAL RESEARCH LABORATORY
WASHINGTON, DC 20390
ATTN CODE 2620, TECH LIBRARY BR

COMMANDER
NAVAL WEAPONS CENTER
CHINA LAKE, CA 93555
ATTN CODE 753, LIBRARY DIV

COMMANDER
AF CAMBRIDGE RESEARCH LABORATORIES, AFSC
L. G. HANSCOM FIELD
BEDFORD, MA 01730
ATTN TECH LIBRARY

DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
WASHINGTON, DC 20234
ATTN LIBRARY

DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
BOULDER, CO 80302
ATTN LIBRARY

DIRECTOR
LAWRENCE RADIATION LABORATORY
LIVERMORE, CA 94550
ATTN DR. HARVIN J. WEBER
ATTN DR. HELMUT A. KOEHLER

NASA GODDARD SPACE FLIGHT CENTER
GREENBELT, MD 20771
ATTN CODE 252, DOC SECT, LIBRARY

NATIONAL OCEANIC & ATMOSPHERIC ADM
ENVIRONMENTAL RESEARCH LABORATORIES
BOULDER, CO 80302
ATTN LIBRARY, R-51, TECH REPORTS

CARNEGIE MELLON UNIVERSITY
SCHENLEY PARK
PITTSBURGH, PA 15213
ATTN PHYSICS & EE
DR. J. O. ARTMAN

UNIVERSITY OF MICHIGAN
COLLEGE OF ENGINEERING NORTH CAMPUS
DEPARTMENT OF NUCLEAR ENGINEERING
ANN ARBOR, MI 48104
ATTN DR. CHIHIRO KIKUCHI

DIRECTOR
ADVISORY GROUP ON ELECTRON DEVICES
201 VARICK STREET
NEW YORK, NY 10013
ATTN SECTRY, WORKING GROUP D

DISTRIBUTION (Cont'd)

CRYSTAL PHYSICS LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MA 02139
ATTN DR. A. LINZ
ATTN DR. H. P. JENSEN

CENTER FOR LASER STUDIES
UNIVERSITY OF SOUTHERN CALIFORNIA
LOS ANGELES, CA 90007
ATTN DR. L. G. DE SHAZER

GEORGE WASHINGTON UNIVERSITY
WASHINGTON, DC 20052
ATTN DR. J. V. RICHARD KAUFMAN, RESEARCH
PROFESSOR OF ENGINEERING ADMINISTRATION

HARRY DIAMOND LABORATORIES
ATTN MCGREGOR, THOMAS, COL., COMMANDER
/FLYER, I.N./LANDIS, P.E./
SOMMER, H./OSWALD, R.B.
ATTN CARTER, W.W., DR., TECHNICAL
DIRECTOR/MARCUS, S.M.
ATTN KIMMEL, S., IO
ATTN CHIEF, 0021
ATTN CHIEF, 0022
ATTN CHIEF, LAB 100
ATTN CHIEF, LAB 200
ATTN CHIEF, LAB 300
ATTN CHIEF, LAB 400
ATTN CHIEF, LAB 500
ATTN CHIEF, LAB 600
ATTN CHIEF, DIV 700
ATTN CHIEF, DIV 800
ATTN CHIEF, LAB 900
ATTN CHIEF, LAB 1000
ATTN RECORD COPY, BR 041
ATTN HDL LIBRARY (3 COPIES)
ATTN CHAIRMAN, EDITORIAL COMMITTEE
ATTN CHIEF, 047
ATTN TECH REPORTS, 013
ATTN PATENT LAW BRANCH, 071
ATTN MCCLAUGHLIN, P.W., 741
ATTN CONRAD, E. E., 002
ATTN FARRAR, R., 350
ATTN KIRSHNER, J., 320
ATTN GLEASON, T., 540
ATTN GIBSON, H., 540
ATTN KARAYIANIS, N., 320 (10 COPIES)
ATTN KULPA, S., 320
ATTN LEAVITT, R., 320
ATTN MORRISON, C., 320 (10 COPIES)
ATTN NEMARICH, J., 320
ATTN FIESSLER, W., 320
ATTN SCALES, J., III, 540
ATTN WILLETT, C. S., 320
ATTN WORTMAN, D., 320 (10 COPIES)